

Impact of the initialization with different ocean reanalysis on forecast bias

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1. Motivation and open questions

Introduction: Strong systematic SST biases in Tropical Atlantic commonly develop in seasonal forecasts among most GCMs^{1,2}. In EC-Earth3, a strong warm surface temperature bias develops in less than a month in boreal winter or summer over Angola-Benguela Area (ABA), and a cold surface temperature bias develops, which is particularly strong in boreal winter, in ATL3 (Figs 1 and 2).

Research questions: What are the mechanisms responsible for the error growth in Tropical Atlantic? What is the impact of the initialization with different ocean reanalysis (ORAS4 and GLORYS) on the forecast bias?

Model: EC-Earth3.0.1, T255L91-ORCA1L46

Simulations: Initialized every 1st May and 1st November between 1993-2009, 4 month forecasts, 10 ensemble runs. Atmosphere and land initialized from ERA-interim. Ocean and sea-ice initialized from ORAS4 and GLORYS2v1 (interpolated to ORCA1L46 configuration).

3. In which start dates is the error stronger in ABA?

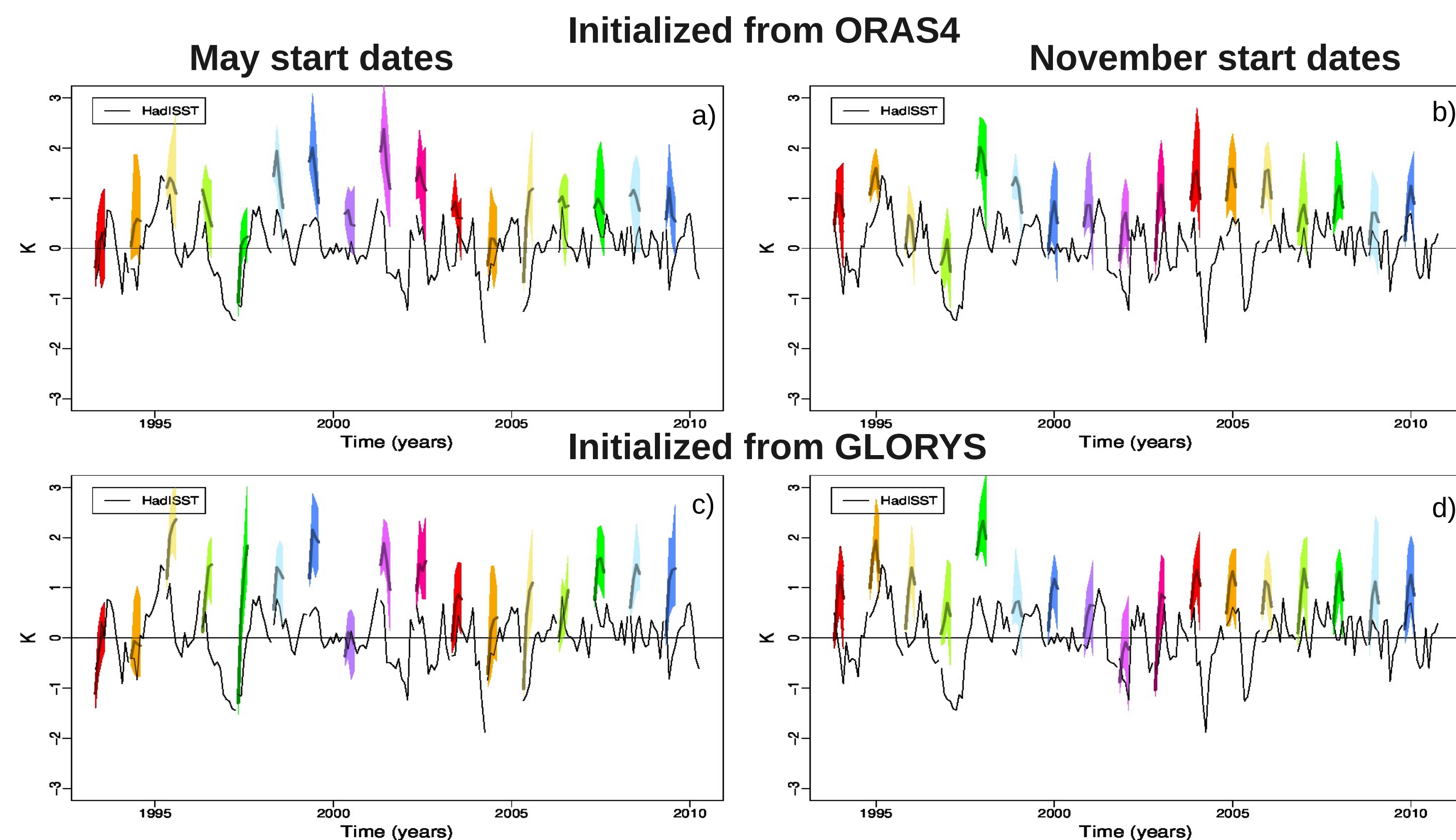


Fig 2: Time series of sea surface temperature anomalies of HadISST (black lines), and of the forecast anomalies (colored lines) with respect to HadISST climatology, for May (left column) and November (right column) start dates, averaged over ABA (box shown in Fig 1d). The forecasts shown in the top row are initialized by ORAS4 and in the bottom row by GLORYS.

4. Is the temperature bias caused by erroneous surface fluxes?

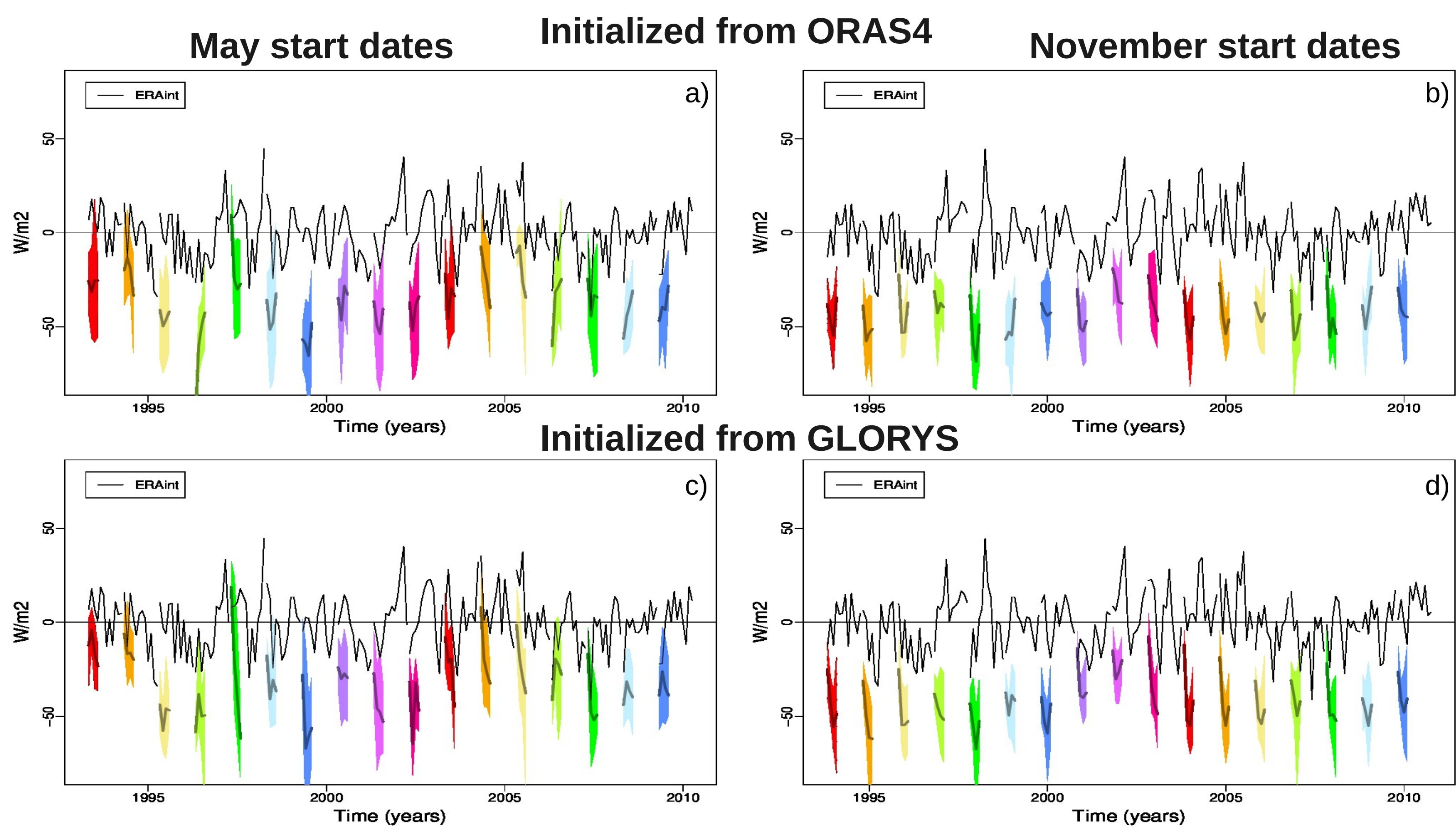


Fig 3: Time series of surface net heat flux anomalies of ERAint (black lines), and of the forecast anomalies (colored lines) with respect to ERAint climatology, for May (left column) and November (right column) start dates, averaged over ABA (box shown in Fig 1d). The forecasts shown in the top row are initialized by ORAS4 and in the bottom row by GLORYS.

6. Tentative remarks & Outlook

- A **strong and fast warm bias** develops over the Tropical Atlantic in forecasts initialized by ORAS4 and GLORYS (Fig 1), in almost all start dates (Fig 2). Initialization with GLORYS results in **slightly slower and weaker** bias development (Fig 1a,e,i,m).
- Monthly mean biases in ABA surface net heat fluxes (Fig 3) denote **less** downward heat flux, implying that, at monthly time scales, surface fluxes **do not cause** the warm surface error.
- But: a warm temperature error over ABA can be caused by reduced ocean upwelling, caused by increased downward heat flux **at the first days** of the forecast⁴. This mechanism can be at work **only during November start dates** (Fig 4b,d). The changes in ocean upwelling need to be further analyzed (work in progress).
- Errors in ocean upwelling can be also caused by erroneous wind-induced Ekman upwelling^{1,2}. However, vorticity differences (used as a proxy to Ekman upwelling) indicate **more** upwelling during May start dates (Fig 4e), and **less** upwelling (5% increase in vorticity) only during November start dates (Fig 4f). The wind, therefore, **does not seem to be the cause** of error in the May start dates.
- Outlook: investigate daily data in more start dates to establish a consistent mechanism; analyze changes in upwelling in ABA region, as well as possible connections with the Equatorial dynamics. Investigate impact of increasing atmospheric/ocean resolution.

2. Biases in near-surface temperature

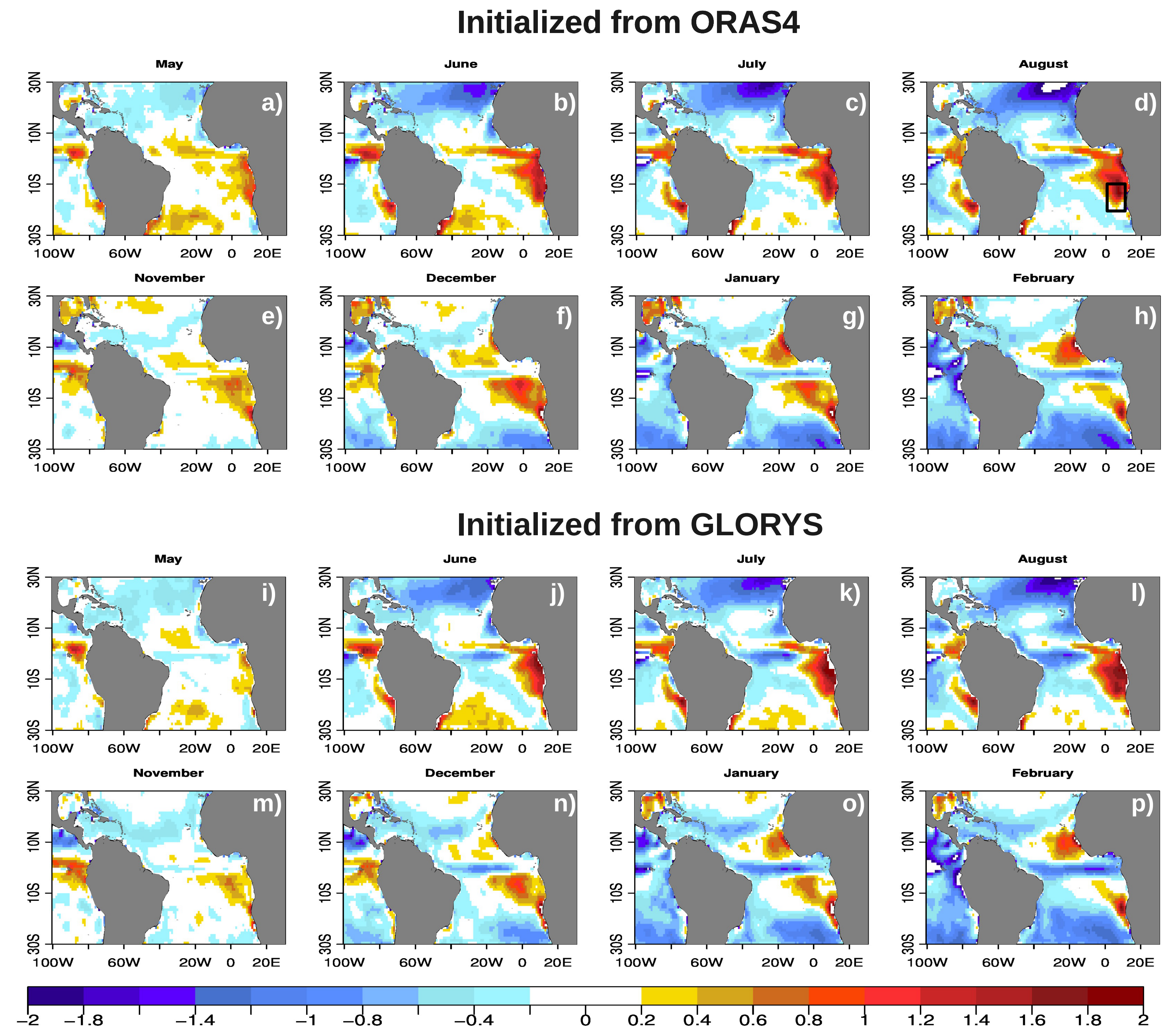


Fig 1: Monthly mean bias (years 1993-2009) of sea surface temperature for simulations initialized from ORAS4 (top two rows) and GLORYS (bottom 2 rows), for May and November start dates, with respect to HadISSTv1.1. The box in d) denotes the Angola-Benguela Area (‘ABA’, defined as the region in 8-15 E, 10-20 S).

5. Fast bias development: daily bias from two forecasts, May 1995 & November 2000

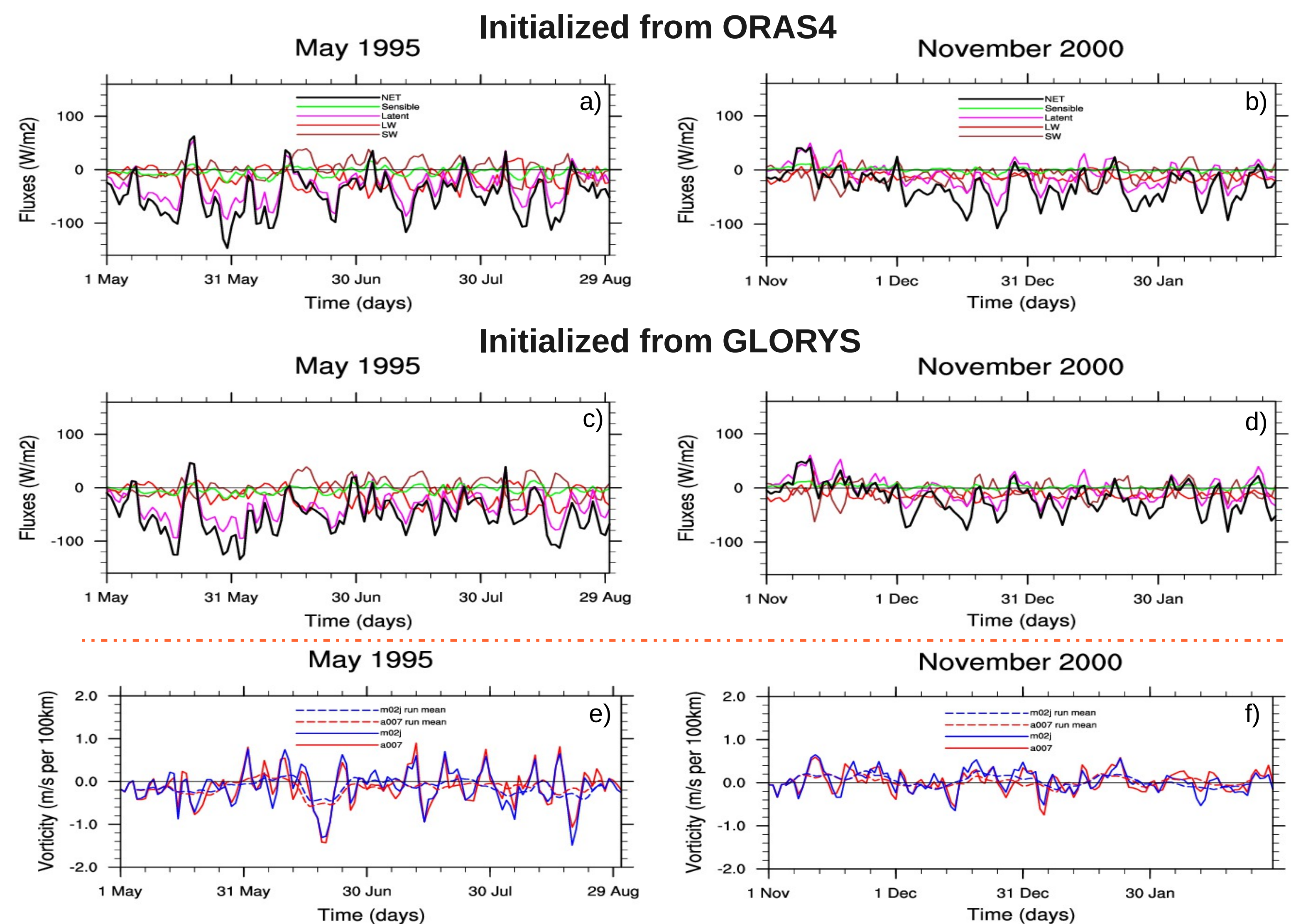


Fig 4: Daily time series of the differences in surface heat fluxes (positive downwards) between model and ERAint, for forecasts initialized from ORAS4 (top row) and GLORYS (middle row), for the forecast initialized in May 1995 (left column) and November 2000 (right column). Bottom row: biases in vorticity, for run initialized by ORAS4 (red) and GLORYS (blue), where dashed lines denote 15-days running means. All plots are for data averaged over ABA (box shown in Fig 1d).

References:

- Toniazzo, T., & Woolnough, S. (2013). Development of warm SST errors in the southern tropical Atlantic in CMIP5 decadal hindcasts. Climate Dynamics. doi:10.1007/s00382-013-1691-2
- Richter, I. (2015). Climate model biases in the eastern tropical oceans: causes, impacts and ways forward. Wiley Interdisciplinary Reviews: Climate Change, 6(3), 345–358. doi:10.1002/wcc.338